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DIVISION OF VETERINARY SCIENCE

FEEDING BONE MEAL TO RANGE CATTLE ON THE COASTAL PLAINS OF TEXAS

PRELIMINARY REPORT

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†As of June 30, 1926.
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***In cooperation with the School of Agriculture.

SYNOPSIS

This Bulletin reports results obtained by feeding bone meal and salt mixtures and finely ground rock phosphate mixed with bone meal and salt to cattle in the Gulf Coast region of Texas. It was found that the bone-chewing habit exhibited by about seventy-five per cent of the range cattle in that region can be broken if each animal is fed daily about three ounces of bone meal mixed with salt. Animals getting this amount of bone meal make larger gains in weight than animals not so fed. Cows fed bone meal reared better calves. It effectually prevented creeps in range cattle, and greatly reduced losses from diseases other than those of an infectious character.

It was found that finely ground rock phosphate when fed alone, or when mixed with salt, or when mixed with salt and bone meal in equal parts did not give satisfactory results.

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PRELIMINARY REPORT

H. SCHMIDT

The results reported in this Bulletin are, in fact, a by-product of some investigational work into the nature and prevention of loin disease, but they are of such far-reaching significance and importance that the writer feels justified in publishing them for the guidance and cognizance of the stockmen.

CATTLE REQUIRE MINERALS

The need of the animal body for various minerals for its upkeep and normal development has long been recognized and many facts have become known regarding an excessive or a deficient supply of minerals for the animal body. While not all known minerals are necessary for, or even utilized by, the animal body, still such minerals as calcium, phosphorus, magnesium, iron, potassium, sodium, sulphur, manganese, iodine, chlorine, and so forth, are always found in the tissues of the animal body in varying amounts. The amount of these minerals required by the animal body varies with the different minerals and depends upon the use to which they are put in the animal body. Thus, calcium and phosphorus are used mainly for building up the bony structures and hence are required in comparatively large quantities, while the other minerals are used more for carrying on the normal metabolism of the body and hence are needed in comparatively small amounts only. Calcium and phosphorus are also excreted in large amounts with the milk for the use and needs of the suckling young, for which reason lactating animals have need for an especially large quantity of these two minerals. If these two minerals are not supplied in sufficient quantity during lactation to meet the requirements of the suckling young, the mother animal will not immediately react by secreting a smaller proportion of these minerals with the milk but it will sacrifice its own welfare and draw upon its reserves, the minerals stored in the skeleton, in order to supply the required amount as far as she is able to do so, and thus enable the young to thrive normally as far as possible. But data at hand indicate that the mother animal, particularly the cow, cannot draw upon her mineral reserves to an unlimited extent but eventually answers with a decrease in the milk flow (2) and in the amount of calcium and phosphorus in the milk even though her ration be otherwise balanced. This cuts down

the amount of calcium and phosphorus available for the suckling young, which, indeed, interferes more or less with the normal development and growth of the latter.

Inasmuch as a large amount of calcium and phosphorus is excreted with the milk, it follows that the lactating animal must have available in its food a large amount of these two minerals, and that if it lacks them, the milk flow must decrease. That a pregnant animal, especially in the advanced stages, has need for large amounts of calcium, phosphorus, and other minerals to satisfy the ever increasing demand of the developing young, goes without saying.

Phosphorus, coupled with protein, is also needed by the animal body in its normal metabolism to build up the muscles, nerves, and other tissues.

The animal takes up these minerals with the food. Inasmuch as the food of the animal is, in the final analysis, derived from the soil, the amount of the minerals found in the food depends upon the amount present in the soil and upon its availability to the plant. Thus, if there is an insufficient amount of these minerals present in the soil there will be a relatively smaller quantity found in the plants growing upon such a soil (1, 8, 3). This is of special significance where only grazing is practiced or only home-grown roughage is fed. Nor do the different kinds of plants utilize and store in their tissues the same amount of these minerals even though they be present in the soil and available to the plant in sufficient quantity. Some plants normally contain more of these minerals than others. Nor are the different minerals distributed evenly throughout the plant, for the stems and leaves usually contain more calcium than the seeds, and the seeds contain more phosphorus than the stems and leaves.

What, now, is the effect upon the animal body in case it does not receive a sufficient supply of minerals with the food? Metabolism and katabolism are constantly going on so that the tissues built up yesterday may be torn down today to be replaced by new tissues if the raw material is available. If suitable raw material is not available, the health of the animal must suffer.

In order that the animal may be able to utilize the different minerals to the fullest extent, they must be available in certain proportions, at least as far as calcium and phosphorus are concerned, for they combine, to a great extent, in the animal body to form certain chemical compounds. A lack of one, or a lack of proper proportion between these two minerals limits the usefulness of both. The more the amount of calcium consumed falls below the minimum requirement of the animal, the less will be the storage of both calcium and phosphorus. For the same reason, the greater the amount of phosphorus consumed in excess of the proportionate amount of calcium, the greater will be the amount of calcium eliminated from the body and lost to the animal.

COMMON SALT OR SODIUM CHLORIDE, IODINE, AND IRON.

Chlorine is found in plants combined with other elements, but the amount contained therein is not sufficient to satisfy the demands of the animal body. It must, therefore, be supplied to the animal in some other form and for that purpose common salt constitutes the cheapest source. One of the main uses of chlorine in the animal body is to combine with hydrogen to form hydrochloric acid, which acid is needed by the animal to carry on the digestion in the stomach. That salt must be supplied to the animal goes without saying. It is common practice to place it before the animals so they can partake of it to suit their individual tastes.

Many dairymen practice the addition of 1 per cent common salt to the rations of their cows, and furthermore allow them free access to salt. This practice seems to give uniformly good results. At the Agricultural Experiment Station of the University of Wisconsin, S. M. Babcock carried out some experiments to determine the effect of depriving cows of salt. For this purpose dairy cows were used which were liberally fed but allowed no salt in addition to what was normally contained in the feed and water. This amount was estimated to be about three-fourths of an ounce daily. Of twenty-three cows that were thus deprived of salt all went for more than sixty days and several for more than six months before any noticeable effects upon their physical condition and milk yield occurred. After being deprived of salt for three weeks the animals became very hungry for it and would lick the mangers and walls of the stall as well as the hands and clothing of the attendants or dirt in order to obtain it. This condition prevailed for varying lengths of time but eventually grave symptoms set in. The cows would fail in health rapidly, showed a rough coat, generally haggard appearance, lusterless eyes, depressed appetite, a rapid decrease in milk yield, and a rapid loss in weight amounting to two to three pounds per day, which, when no salt was given at this critical period, terminated in collapse and death. If, however, salt was allowed at this time, a gradual recovery took place. In one instance potassium chloride instead of sodium chloride (common salt) was allowed, and in this case also a gradual recovery took place, which indicates that chlorine is the essential element needed. When such cows were again allowed free access to salt, it was found that the cows would eat eight ounces to one pound of salt at once. In most cases it was found that the cows would consume three to four times the usual amount for several months. (4).

Iodine. A lack of iodine or an insufficient supply of iodine has a decidedly deleterious effect upon the health of the animal, or at least upon its offspring. In Texas, as a rule, the animal finds enough iodine available in the food it consumes, but some regions are known where this is not the case. In such regions new-born pigs are either hairless or possess a scant growth of hair, and more frequently have

goiter or big-neck. Sheep and goats are similarly affected, while newborn foals, though showing neither hairlessness nor goiter, are weak, seldom able to stand, and usually die. An addition of iodine to the feed of the mother animal prevents the trouble (9), the amount needed being two grains per day for sows and proportionately more for larger animals. Where such symptoms as enumerated above appear, it is advisable to try the suggested treatment.

Iron. The lack of or an insufficient supply of iron leads to anemia, which in turn interferes with the oxygen-carrying capacity of the blood and eventually with all the vital activities of the body.

CALCIUM, PHOSPHORUS, AND MAGNESIUM

The need of the animal body for calcium, magnesium, and phosphorus is so great and these elements have such close chemical affinities in the body that they are best considered together. The greater amount of these elements absorbed by the body is used in building up the skeleton and it is here where the greatest disturbance is noted in case where these minerals are insufficient or unavailable. Not only do disturbances develop in the young growing animal but also in fully matured animals, although from a pathological standpoint the two conditions are directly opposite in their development. The disturbances referred to are such as osteoporosis, osteomalacia, rickets, legweakness, paralysis of the hind quarters, creeps, etc. Some of these conditions are not yet fully understood, while several of them should probably be classed under one head. All of these conditions affect the skeleton of the animal, especially when the animal is not yet fully mature. The effects of such deficiencies need not always become manifest directly in the animal concerned, for frequently they come to light only in the offspring inasmuch as the young is either born prematurely, or is insufficiently developed, and may show the diseased conditions of the bones mentioned above either at birth or develop them soon thereafter. Especially young growing animals,—and among these the more rapidly growing animals,—suffer severely enough from the lack of calcium and phosphorus that unmistakable symptoms may develop in a comparatively short time.

Minerals serve a number of important purposes in the animal body. It is a well established fact that animals receiving no minerals (ash) at all in their feed will die sooner than if no feed at all were taken (1). This fact suggests that in the course of metabolism and katabolism certain substances are formed in the body which are injurious to the animal body and which, under normal conditions, are coupled to available minerals and thereby converted into non-injurious substances. But there are also other important functions which minerals serve. The greater part of the bones is composed of calcium and phosphorus, together with a smaller amount of magnesium, fluorine, and other elements. Minerals are also present in the muscles and other tissues of the body, where they perform important functions. They are, further-

more, essential to the body to help maintain a proper concentration and neutrality of the blood, assisting the body in getting rid of excess acids, etc. There is evidence to show that the phosphates also play an important part in the digestion and utilization of food (3).

RICKETS OR RACHITIS

Without endeavoring to exhaust the fund of facts which have become known about the disturbances of the skeleton named above, let us consider the most important ones briefly. It is a well established fact that rickets develops in immature animals, especially when they are still quite young. Even suckling animals sometimes develop it and, according to Dammann (11), healthy suckling animals become ill if they are placed on a mother animal whose young is affected with rickets. We have seen above that normally the milk contains enough calcium and phosphorus to insure a normal development of the young, but if the milk secretion is rather scanty the amount of calcium and phosphorus may no longer suffice to cover the needs of the young. More recently another factor, vitamin D, or antirachitic factor, has been found, which has a decided influence upon the calcium and phosphorus metabolism. A lack of this antirachitic factor leads to the development of rickets even though a sufficient supply of calcium and phosphorus may be available. An insufficient exposure to direct sunlight has also been shown to have a tendency to produce rickets.

After the young animal is weaned and becomes dependent upon vegetable food for its source of calcium and phosphorus, rickets may develop when the calcium and phosphorus content of the food is too low. This may be the case following unfavorable weather conditions, especially during severe and protracted drouth when the lack of moisture in the soil will prevent the calcium and phosphorus constituents of the soil from going into solution and hence will not be available to the plant. Vegetation growing on acid soil, on soil deficient in calcium and phosphorus, or on low swampy marshy soils is frequently very low in its content of calcium and phosphorus, and animals forced to subsist on such vegetation for a long time very often develop rickets or other disturbances of the bones. Since the metabolism of calcium and phosphorus is to a great extent interdependent, it follows that both elements need not be simultaneously lacking in the food, but that the lack of one will as certainly produce these disturbances as the lack of both. An excess of acid in the food, an unfavorable relative proportion of protein, carbohydrates, and fat in the food, and in some cases chronic digestive disturbances may also cause diseased conditions of the bones (6).

Under such conditions the animals show a depraved appetite, will lick on wood such as wooden walls, partitions, fence posts, on dirt, manure, rocks, bones, etc., or may even try to consume such substances. Digestive disturbances may also be present. Disturbances of the nervous system may also become manifest, the animals showing twitching

of the muscles or even convulsions, which may vary greatly in their severity and duration. The animal soon shows soreness while walking and soon becomes lame. Some animals may even refuse to stand on their feet but instead will try to support their weight on the carpal joints. The animal eventually becomes emaciated and unless conditions become more favorable usually dies.

The bones, especially those of the extremities, show a lack of development in the longitudinal direction, are frequently thicker than normal, and exhibit a more or less pronounced thickening near the joints. Such bones are soft and spongy and for that reason frequently bend under the weight of the body and may even break. In the more severe cases such thickening and also distortion of the bones may also be observed on other parts of the skeleton, especially on the head and ribs. The bones may be so soft that they can easily be cut with a knife. They are incompletely ossified and hence lighter in weight than normal bones.

OSTEOMALACIA

A disease with symptoms and lesions similar to those of rickets may also be observed in mature animals and is known as osteomalacia. The true cause or causes of this disease have as yet not been definitely established in every case, but it is well known that it, too, will occur under conditions similar to those just described, although the pathological lesions develop in the reverse direction. That is, the already mature bone becomes decalcified when not enough calcium and probably phosphorus is available to the animal to replace the amount used up in its normal metabolism, thus producing the lesions already described. As a result of these disturbances of the metabolism the animals become emaciated and weak, frequently suffer fractures of the bones without the application of external violence, and in some seasons and on some farms many animals may even abort. Of the young that are born alive, some of them soon die without showing symptoms of any specific disease.

The disease develops under conditions similar to those described above, but it could not in all cases be shown to be due entirely to the lack of minerals, although this appears to be the principal cause. The disease has also been observed to persist even after an abundance of mineral matter was supplied and in such cases the cause of the disturbance in mineral metabolism is usually attributed to a derangement of the functions of the endocrine glands, lack of vitamins, an abnormal bacterial flora of the intestinal tract which produces unusually large amounts of acid (10), an excessive amount of crude fiber in the feed, an improper proportion of the minerals present in the food, an unfavorable proportion of protein, carbohydrates and fats (6), etc.

It should be emphasized here that the diseases above discussed need not always terminate unfavorably, but that their course depends upon the severity of the unfavorable conditions of food to which the animals are subjected. When these conditions again become favorable the animal may make a surprisingly rapid recovery.

CREEPS

A condition frequently met with in the Gulf Coast region of Texas, on the more sandy soils in other parts of the State and adjoining states, commonly known under the name of "creeps" and not yet thoroughly investigated is undoubtedly closely related etiologically to the above described conditions. It is observed especially in dry years and in all classes of cattle, though young cows with calves are most frequently affected. It often causes appreciable losses. It has been observed only in range cattle.

The animals become thin and weak and soon show a peculiar stiff, creepy gait as though it were painful to walk. Sometimes distinct

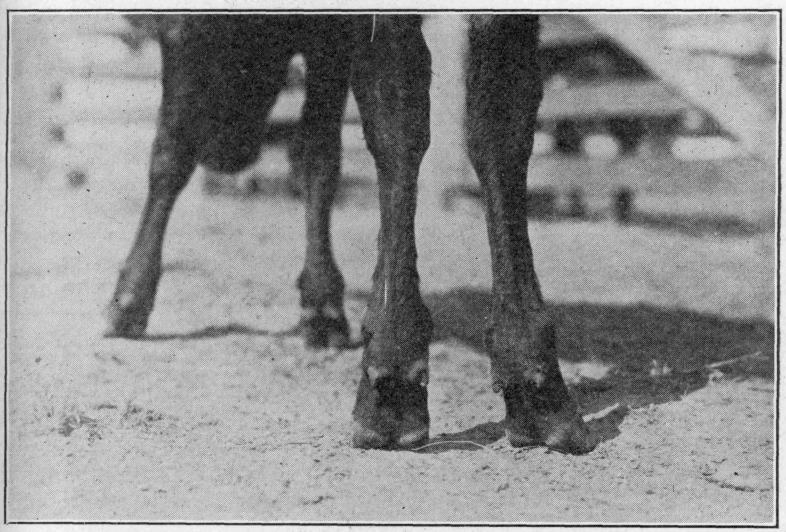

Figure 1. Bony enlargements on the distal end of the metacarpus and metatarsus; sometimes observed in young animals in the area under discussion.

lameness and stiffness become manifest. Swelling of the joints proper has not been observed by the writer. In young animals distinct circumscribed enlargements at the distal end of the metatarsus and metacarpus are sometimes observed, although these enlargements are not characteristic for creeps (Figure 1). When the condition grows worse, the animal lies around a great deal, does not graze normally, and goes to water only seldom. The animal consequently becomes drawn and gaunt, and the feces become hard, indicating that the digestive system no longer functions properly. Animals, when in this condition, no longer take a sufficient amount of food and water; hence they rapidly grow weaker and eventually die if left to their own resources. If, however, the animal be taken up in time, properly

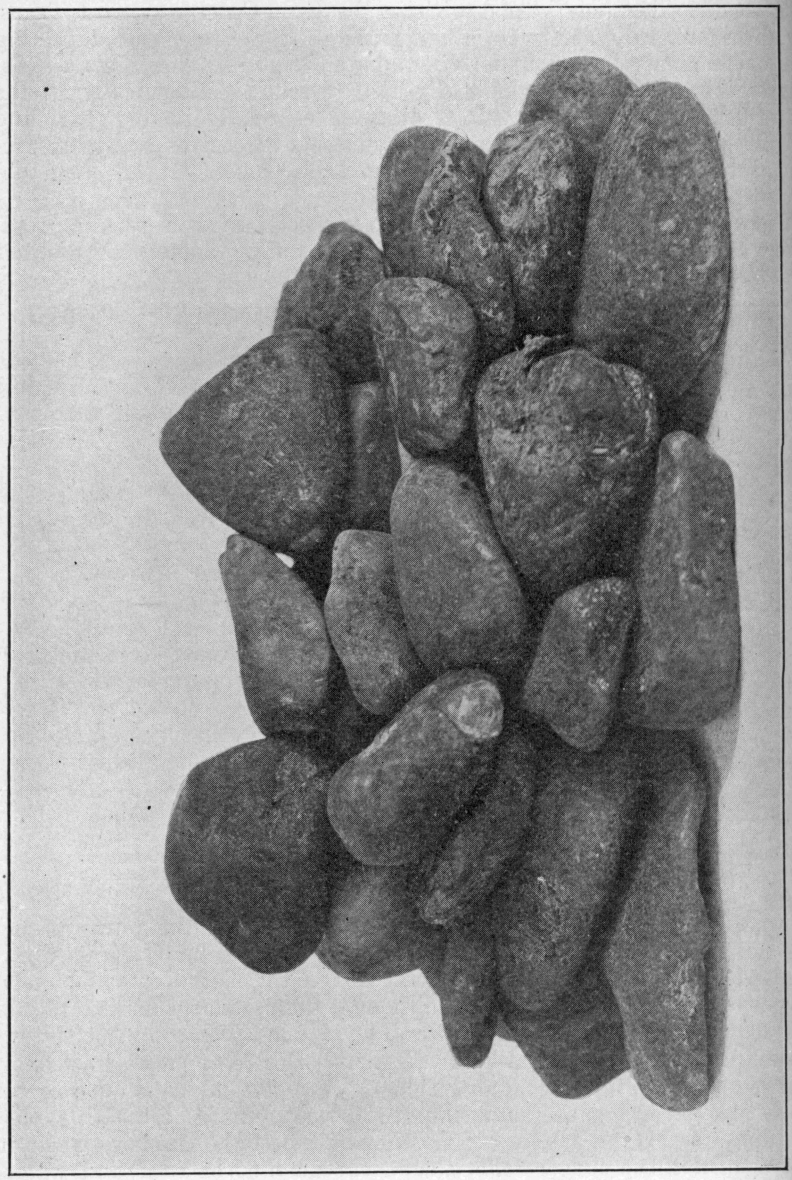

Figure 2. Gravel rocks removed from the rumen of No. 24. Natural size.

cared for, and given nutritious food, especially food rich in mineral matter, a rapid recovery takes place. Animals affected with this trouble are usually spoken of as creepy.

Bones from animals that have died from creeps have not yet been examined to determine the changes taking place therein or to establish its relationship to osteomalacia. Such examinations are projected for this station soon.

The foregoing short outline may suffice to call attention to the need of the animal body for minerals and the conditions that may develop in case of a lack of deficient supply of minerals. Let us now consider some results obtained by feeding calcium and phosphorus to animals in the form of raw feeding bone meal.

FEEDING BONE MEAL TO ANIMALS

When the writer undertook the investigation of loin disease in the Gulf Coast region of Texas he was struck by the large number of animals observed to chew bones, which led him to suspect some relationship between this habit and loin disease. In the course of the studies it was found that these so-called bone-chewers would not always stop at chewing bones, but that many of them would also chew sticks, leather, tin cans, ropes, hair ropes, rawhide whips, cast-off horns, rags, pasteboard and rocks. One animal was even observed to chew a piece of terrapin to which the fresh entrails were still clinging. Since there are no trees in the Field Laboratory grounds (excepting the woody stems of the coffee bean, *Daubentonia longifolia*) and the other objects mentioned above are only occasionally found on the grounds, our cattle have not often been observed to chew all of such objects, but it was found necessary to carefully guard all ropes, saddle and harness leather, and particularly rawhide whips. One can truly say that the animals were suffering from allotriophagia. Concerning rocks, the conditions were somewhat different. There are no rocks whatever on the surface of the ground excepting along some deep drainage ditches, two of which cross the grounds to take off the surface water of the poorly drained land. Among the soil removed from the deeper layers white calcareous rocks can be found. Cattle are often observed to stand along the dumps of the ditches picking up and chewing these rocks. During the course of some concrete construction work on the grounds at the main pens some gravel was left after the work was completed. This gravel was left on the ground in a pen in which the cattle were kept only a short time once every month during weighing operations. It was soon discovered that many of the bone-chewers when in this pen would pick up and chew some of this gravel. When one such animal, cow No. 24, later died, seven hundred and seventy-eight grams (twenty-six ounces) of gravel rocks ranging in weight from five grams to forty-eight grams and comprising thirty-eight pieces were recovered from the rumen of this animal (Figure 2). Undoubtedly more will later be recovered from some of the other animals still living.

It should be stated here that not all animals manifested a desire to chew these objects, nor that those that did show a depraved appetite exhibited it to the same degree. The greatest uniformity was, however, shown in the bone-chewing habit; so it was thought well to use it as an index to guide us in our work (Figure 3). It is indeed surprising how expert some animals get to be in locating bones in the pasture. The writer has often observed when cattle were being driven through a pasture that one or the other animal would suddenly leave the herd, walk some distance away, pick up a bone and stop to chew it. It was interesting to observe an old cow in this respect. The animal in question, cow No. 84, was a constant bone-chewer but would absolutely refuse to eat a mixture of bone meal and salt. She was always placed

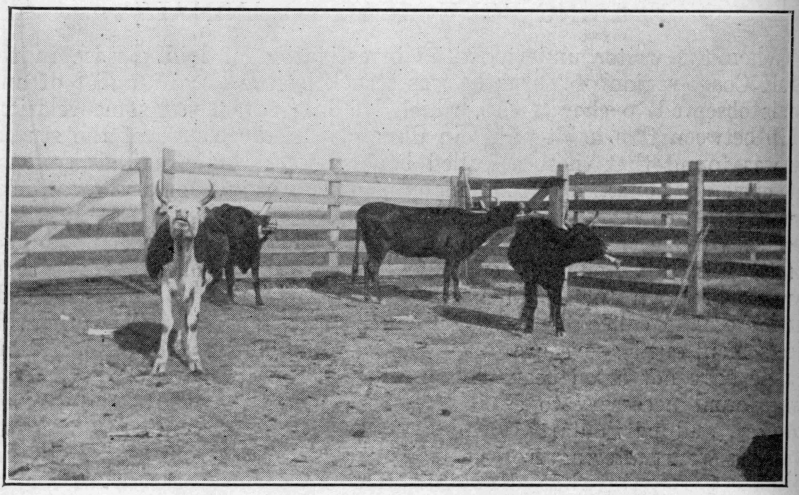

Figure 3. Bone-chewers at work.

in the pen together with the other cattle to be fed the bone meal and salt mixture, but always would she stand off in one corner ruminating contentedly. However, if an old bone was thrown into the pen at some point distant from the animal and without the animal's seeing it done, it would not be many minutes till she had found it and was chewing it. Another example: a close rail pen had been placed around a carcass in the pasture in order that the bones might be saved. When the bones were finally collected it was observed that a deep path had been worn into the ground close around the pen by the animals walking around the pen in effort to get to the bones.

The animals do not always seem to exercise much discretion as to the wholesomeness of the bones they chew. While some animals will chew only sun-bleached bones, others are found that will not despise a foul-smelling bone or even the putrid meat still clinging to such a

bone (Figure 4), or a piece of old hide that has not yet completely decayed. Occasionally an animal may be seen licking on the partially exposed bones of a foul-smelling carcass.

The facts related above have probably been observed by many cattlemen. Few if any ever gave the matter a serious thought, for they had seen so many cattle chewing bones that it no longer aroused their curiosity. In fact, many consider it a normal habit of the beast. They had perhaps unknowingly suffered heavy losses because of it but did not realize that the animals were in fact showing the usual symptoms of a lack of mineral nutrients. But this is not surprising, for many of the bone-chewers were in such a good condition that one would not readily suspect a lack of anything in the feed.

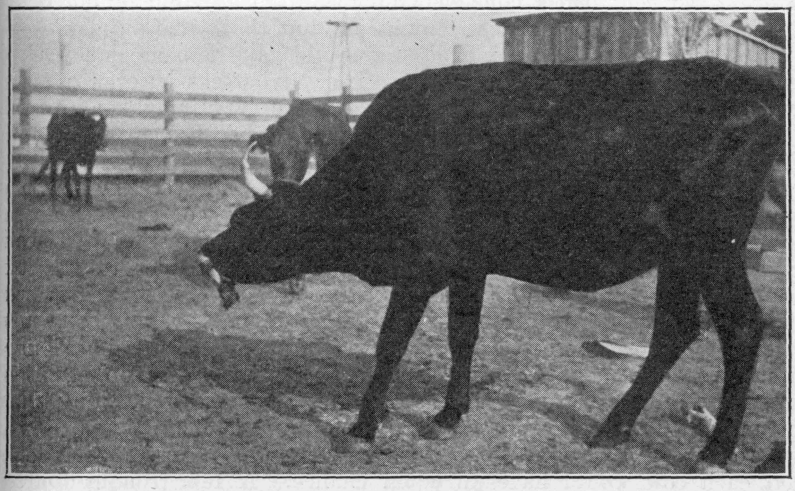

Figure 4. Cow No. 11 chewing the putrid meat still clinging to an old bone.

The writer had no idea of the number of animals that would chew bones until the Loin Disease Field Laboratory was established near Bammel, Texas, in Harris County, and eighty-eight animals put on test. These animals were all branded with a number on the left shoulder so that they could be readily identified and a careful record could be kept. The cattle had all been bought from one owner about ten miles from the grounds of the Loin Disease Field Laboratory, where they had been kept for about a year. Since the cattle were bought in connection with our loin-disease investigation, they were divided into three lots and one-half of each lot placed upon a different mineral mixture to observe the effect upon loin disease. The bone-chewing habit was used as an index to determine whether loin disease was in some way related to this habit and the mineral mixtures were fed to control the bone-chewing habit. The animals were assigned to

and placed in the different lots and upon the different mineral mixtures or as controls before they were tested for the bone-chewing habit for the first time. The only apparent exception to this procedure was that all cows with calves were placed together in pasture No. 3. The sole purpose of feeding the mineral mixture thus was to definitely break, if possible, one-half of the animals of the bone-chewing habit and to allow the other one-half to follow their natural inclination in this respect but to confine them to the same pasture as the other animals in the lot to which they had been assigned as controls. Once a week all animals in each lot were tested for bone-chewing by placing them in a corral together with some bones which had been picked up on the prairie. On the first test thirty-seven of the eighty-eight animals were recorded as bone-chewers, but before many weeks passed a total of 67 or 77 per cent had a bone-chewing record. It should be noted that the animals did not chew bones regularly, but that some animals would only occasionally take a bone, others would take a bone one week or for several weeks and then skip a week or two weeks or even a month or so, while still others would chew bones at very irregular intervals.

Let us now consider the mineral mixtures that the animals in the different pastures had been getting. Pasture No. 4 contained thirty-eight cows, twenty of which were placed on a mixture made up of two parts of raw feeding bone meal and one part of salt. Fine salt was chosen so that the mixture would be made up of granules of nearly equal size and thus prevent the finer bone-meal granules from sifting to the bottom and being lost. Twenty-four cows with calves were placed in pasture No. 3, ten of which were offered straight bone meal. Twenty-four cows were placed in pasture No. 2 and were offered finely ground rock phosphate as a carrier of the calcium and phosphorus. All cows receiving mineral were placed in a corral every morning where the mineral mixtures were placed in small individual boxes, allowing two to three boxes more than there were cows on test in the lot so that each cow would have an equal chance. A few troughs fourteen feet long were also used and found quite satisfactory. While the test cows were being fed the control cows had access to salt in an adjoining corral.

Only so much of the bone meal and salt mixture or of the finely ground rock phosphate was placed in the boxes as it was thought the animals would consume, but in every case the maximum amount allowed was such that this amount contained three ounces of bone meal for each animal per day. In this respect we were guided by the number of animals that would eat the mixture and the probable amount that each animal would consume. The amount consumed varied not only with the individual animal but also with the season of the year.

Table 1. Monthly Bone Meal Consumption of Cows (in Ounces).

Cow No.	1924						1925												1926			
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April
1	.....	.....	54	77	86	73	91	82	69	26	32	68	71	93	85	66	80	81	64	18	39	39
14	.....	.....	73	68	88	70	85	84	42	30	39	58	55	90	75	71	66	81	66	15	38	7
19	.....	.....	.....	23	80	70	88	62	24	31	31	45	52	54	70	66	85	81	66	14	51	51
21	.....	.....	32	44	66	65	85	62	26	29	47	61	62	91	68	61	82	74	66	26	33	7
34	.....	.....	.....	.....	58	74	90	84	58	77	47	72	62	93	90	87	87	81	66	42	79	56
35	.....	.....	.....	.....	81	72	87	80	38	22	8	24	62	81	80	48	67	75	63	21	43	23
78	.....	.....	39	41	51	21	74	40	15	17	23	30	31	54	60	4	6	0	24	1	10	5
83	.....	.....	71	87	86	79	93	84	63	86	73	75	81	93	90	87	85	81	63	31	45	59
8	18	21	23	28	23	24	35	18	1	57	76	42	46	87	87	27	56	81	66	14	36	31
29	63	84	81	83	90	78	93	84	44	5	0	50	67	93	90	87	84	81	30	10	56	63
32	61	47	66	63	76	78	90	84	53	38	74	75	61	93	85	24	51	78	66	12	56	18
41	77	76	75	76	83	78	93	82	52	61	84	76	86	93	90	72	87	81	66	19	46	32
49	57	23	65	41	56	76	76	72	9	39	64	68	68	85	81	32	21	12	52	8	9	0
55	65	73	63	81	88	76	91	84	59	57	80	70	77	90	87	77	87	78	62	26	76	68
63	66	68	67	76	86	75	72	64	35	45	59	63	70	83	85	87	87	79	63	26	45	29
67	71	43	59	79	90	78	89	84	78	49	85	76	87	91	90	87	87	79	66	30	49	11
79	27	21	29	41	.....	36	.....	.....	4	28	30	49	60	44	48	5	6	8	23	0	27	11
88	39	59	49	33	62	68	63	66	33	61	74	75	81	90	90	64	78	78	66	15	67	39
93	59	53	48	64	60	51	22	38	16	38	57	56	81	90	90	83	79	81	50	14	50	26
96	75	81	76	86	88	78	93	84	63	45	9	16	16	16	65	72	66	81	62	10	45	18
58	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	59	76	81	90	90	85	78	81	64	16	52	50
59	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	74	78	66	84	83	65	82	73	42	5	12	21
69	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	81	71	77	93	64	57	66	79	58	15	45	26
81	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	78	75	80	93	82	52	85	79	46	16	23	60
11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	59	69	87	93	90	90	87	75	30	30	58	46
15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	0	0	17	90	90	87	75	66	39	29	14
31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	58	78	90	93	90	90	87	75	31	25	65	52
43	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	34	72	86	93	84	79	82	75	31	14	37	54
61	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	55	78	90	93	77	80	84	68	66	38	57	21
68	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16	57	57	50	57	31	48	50	50	11	7	8
71	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	43	76	86	90	83	83	87	69	64	40	61	37
76	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	53	76	90	93	90	90	87	75	28	36	67	53
82	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	51	72	86	93	90	89	84	75	57	19	47	40
86	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	51	73	87	93	88	90	87	75	66	31	67	48
95	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	47	69	83	93	90	86	82	70	32	21	34	45
117	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	68	75	87	90	90	90	85	81	66	31	64	29
131	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	54	69	83	90	90	88	87	81	66	34	53	10
136	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23	62	84	91	88	81	75	81	66	16	45	26

No difficulty was experienced as a whole with the cows in pasture No. 4 in getting the animals to eat the mixture with the exception of cows Nos. 84 and 92. Cow No. 84 consistently refused to eat the mixture and was the expert in finding bones when cast into the corral referred to previously, while No. 92 would eat a little occasionally. After a thorough trial both of these cows were later discontinued as test cows and placed with the control cows in pasture No. 4.

With pasture No. 3 some difficulty was experienced in getting the test under way. It will be recalled that these were the cows with calves, and some of them got rather poor and seven of these developed creeps, so that it was deemed advisable to place such cows on some concentrated feed in order to save them. Thus, cows Nos. 19 and 37 of the test animals and cows Nos. 4, 7, 13, 35, 38, and 42 of the control animals were placed on cottonseed cake before the experiment was under way three weeks. But the other cows on test did not relish the pure bone meal. They would hardly touch it; however, if some bones were thrown into the corral the bone-chewers would eagerly grab them and chew on them. The consumption of the pure bone meal was so unsatisfactory that thirty-nine days after the beginning of the experiment it was decided to add some salt to it. Therefore, after August 2, 1924, these cows were offered a mixture of three parts of bone meal and two parts of fine salt. The cows soon got on to this change and thereafter the consumption was much more satisfactory. This fact was also reflected in the condition of the test cows in the early spring.

FEEDING ROCK PHOSPHATE

The greatest difficulty, however, was experienced in pasture No. 2, where the test cows were at first offered finely ground rock phosphate alone. Ten of the twelve cows on this test were bone-chewers as were also seven of the control animals. On the first day eight of the test cows "tasted" the rock phosphate, but on the following two days none would touch it. It was next mixed with fine salt at the rate of two parts of rock phosphate and one part of salt. This mixture was offered during the next ten days, but the cows would not eat it. It was then mixed at the rate of equal parts of rock phosphate and salt and offered for seven days with the same result. It was next mixed at the rate of one part of rock phosphate and two parts of salt but the consumption during the following fifteen days was still negligible. An attempt was then made to increase the consumption by sprinkling a little cottonseed meal over the mixture after the latter had been placed in the individual boxes, but now the cows would lick up the cottonseed meal and leave the mineral mixture in the box. Three weeks later the mixture was again changed to one part rock phosphate, one part salt, and one part bone meal. Even this mixture was refused by the cows, but in order to give it a fair trial cottonseed meal was again made use of to coax the cows into eating it. When this was done the consumption increased and now varied between one and one-half to two pounds of

the mixture per day for twelve animals and eventually to three pounds per day, but the cattle did not relish it very much, for as soon as the cottonseed meal sprinkled on top was cleaned off the cows would start milling around from box to box till finally a few of the best eaters would clean up the mixture. After a thorough trial which lasted till May, 1925, the consumption was not found satisfactory and for that reason the mixture was abandoned, for, unless it was far better relished than in this trial, it could never meet the requirements of a practical application. During January, at the time this test was still in progress, all the test cows on this mixture became so weak that it was deemed advisable to place them on cottonseed cake. It was not possible with the amount of the mixture consumed by the cows to break the bone-chewing habit of a single animal. It thus appears that this mixture is not very effective in meeting the mineral requirements of cattle.

THE EFFECT OF FEEDING BONE MEAL UPON THE ANIMAL

During the first year of these tests the bone-chewing habit and the general condition of the animal as judged by the eye were the only indicators available. The latter, however, was not considered precise enough to furnish definite proof, for one's judgment in this respect is not reliable enough to decide such a weighty question. It was, therefore, found necessary to install scales at the beginning of the second year and to weigh the cattle at regular intervals.

EFFECT UPON BONE-CHEWING HABIT

Concerning the effect upon the bone-chewing habit but little need be said. All test cows chewing bone at the beginning of the experiment were eventually broken of this habit although it required as long as five months and longer to break up the bad ones. The time required to break an animal of this habit depends, of course, upon the amount of bone meal and salt mixture it will eat, and hence it was found that the hearty eaters could be more quickly broken than the delicate eaters. Even after a month of bone meal feeding one can note that the desire for bones, even of the bad chewers, has received a decided check and that bones are no longer taken so greedily, for a bone now thrown to an animal may not be picked up, but the animal may play with it and roll it around on the ground for a while, eventually to walk off and forget it. A subsequent test may show the same result and soon thereafter the animal may no longer take notice of bones thrown to it. Other bone-chewers, however, may continue to either play with the bones or actually chew them at the weekly test for a long time. It appears, however, under the conditions dealt with here, that not all animals consume enough of the bone meal and salt mixture to permanently break them of the bone chewing habit, for in the course of the experiments four animals were observed to again chew a bone during the second summer of the experiment, after they had been

broken of the habit during the previous summer. It should be borne in mind that not all animals will continue to eat the bone meal and salt mixture every day in the year with an even regularity. Some animals, after eating the mixture with great daily regularity for a long time will suddenly stop eating it for even as long as a period of four to six weeks or consume it more or less irregularly for a time, but such animals, as a rule, always come back and eat it regularly again. Following the first winter, it was also observed that as soon as the green grass came out in the spring all test animals would refuse to eat bone meal and salt mixtures almost entirely for a period of five weeks, after which time it was again consumed with great regularity. This result was noted in all pastures alike.

EFFECT UPON THE CONDITION OF THE ANIMAL

The most striking effect of the feeding of bone meal was reflected in the condition of the animal. Thus, our records show that the animals fed bone meal and salt passed the first winter in a much better condition than the control animals. Let us consider the different pastures separately. Of the thirty-one animals that survived the winter in pasture No. 4 seventeen were test animals and of these cows Nos. 84 and 92 would not eat the mixture. It may be stated here that cow No. 84 calved in November, 1924, got creepy in December, and was placed on cottonseed cake to save her. Of the remaining fifteen test animals two were placed on cottonseed cake late in December because both had recently dropped calves and were nursing them, but neither of them showed signs of creepiness. Of the fourteen control animals in the same pasture a total of seven cows had to be placed on cottonseed cake, three of which had young calves and were nursing them while four had no calves. If we class No. 84 and No. 92 as controls, for such they were in fact, then we would have eight out of sixteen controls on cottonseed cake during the winter while only two out of fifteen test animals had to be thus fed. And if we add control animal No. 73, which was recorded as creepy during November, 1924, and which perished in the severe freeze late in December, then the scales are turned still more in favor of the test animals. Of the latter all but three calved during the winter or early spring while of the controls six did not calve.

It must be borne in mind that the cows with calves were placed in pasture No. 3 and were fed bone meal alone. They did not show a satisfactory consumption, however, until it was changed to a mixture of three parts of bone meal to two parts of fine salt. This was done on August 2, 1924. There was, therefore, not much opportunity for the effects of the bone-meal consumption to assert itself before winter was at hand and one would expect this fact to be reflected in the condition of the animals during the winter. Even at the time this change was made some of the cows, both test and controls, had to be placed on cottonseed meal to which a little bone meal was added, for they were getting very thin and several of them were creepy already. Thus, of

the twenty-three remaining cows in this pasture nine were recorded as either very poor or creepy and placed on feed on or before August 16, 1924. To this number four more had to be added before October was at hand, making a total of thirteen out of twenty-two cows now remaining that had to be placed on feed and this in spite of the fact that there was an abundant supply of grass in the pasture. This fact should be kept in mind, for it is hardly conceivable that under such conditions the cattle industry can flourish. The fact that drouth prevailed during the late summer may have had an influence, but drouth also prevailed during the following summer when an opportunity was afforded to compare a larger number of cows on bone meal and salt mixture with similar control animals, the outcome of which was very satisfactory and in favor of the bone meal mixtures.

Winter was already too close at hand when the remaining cows in pasture No. 3 began to show a real taste for the mixture and notwithstanding that by December 1 all calves were weaned, it was found necessary, on December 27, to place the last of the cows in this pasture on cottonseed meal for the remainder of the winter. It should be kept in mind, however, that once a cow was placed on test she received her respective mineral mixture irrespective of any other change that might have been made.

It was in the following spring, however, that the consumption of bone meal and salt mixture began to tell its story. The test cows became sleek and began to put on flesh much sooner than did the control cows. They now carried more belly and undoubtedly were growing larger. They soon did not look like the same cattle of the previous summer. Since all animals in this pasture were eventually placed on cottonseed meal during the winter, they all had an equal chance and the differences now apparent must be attributed to the bone meal and salt mixture. Such was the status of pasture No. 3 when, on July 17, 1925, the animals were weighed for the first time, for early in the summer of 1925 scales were installed in order that the cattle might we weighed periodically and that a better presentation and objective demonstration of the change in condition of the animal might be had.

As already outlined, the cows in pasture No. 2 on rock phosphate, bone meal, and salt in equal parts did not eat this mixture very well; and hence the results were not expected to be satisfactory in the end. It was, therefore, finally decided to abandon this mixture entirely, and on May 8, 1925, it was changed to a mixture of bone meal and salt in equal parts.

The result of this poor consumption was, that on January 25, 1925, all cows on test in pasture No. 2 were getting so poor that cottonseed meal was added to their mixture at the rate of one pound per head per day, and this was continued till March 6, when green grass came on and all cows on test irrespective of the mixture fed refused to eat their respective mineral mixtures. But even with the cottonseed meal added four of the remaining ten cows on test, Nos. 31, 43, 76, and 82,

developed creeps during April, 1925, and were creepy at the time the mixture was changed to equal parts of bone meal and fine salt.

Of the ten control animals in this pasture that survived the winter, five were placed on cottonseed meal during the winter and one of these succumbed from poverty in the latter part of March after it had calved. There is no doubt that ticks were a contributing factor. Of the other five control animals that were not placed on cottonseed meal, four, Nos. 18, 45, 57, and 74, showed a light attack of creeps in November but improved later, two of which, Nos. 45 and 74, again developed creeps during the following summer after they had calved.

CONCLUSIONS FROM FIRST YEAR'S OPERATIONS

In drawing conclusions from the results obtained during the first summer, fall, and winter it must first be decided whether the cows in pasture No. 2 and pasture No. 3 could really be considered as having had sufficient time or as having consumed a sufficient amount of the mineral mixtures supplied to declare it a fair and valid test to show the maximum efficiency of the mineral mixture as affecting the condition of the animals during the first winter. The writer is of the opinion that this is not the case, for the cows in pasture No. 3 did not begin to consume a satisfactory amount of it until the middle of September, 1924, while the cows in pasture No. 2 on rock phosphate, bone meal, and salt in equal parts, did not begin to consume their maximum amount of three pounds of the mixture for ten cows until the middle of November, 1924, which amount they continued to consume till March 12, 1925, when green grass came on and all cows stopped eating their mixture. If this amount of the rock phosphate, bone meal, and salt mixture consumed during the time indicated is considered sufficient to supply the animals with the needed amount of calcium and phosphorus, then it must be concluded that the mixture was a dismal failure, for the animals could be neither broken of the bone-chewing habit nor be kept from getting creepy.

In contrast to this the results obtained in pasture No. 4 on two parts of bone meal and one part of salt are strikingly different. Of the fifteen animals on bone meal and salt mixture, only two animals had to be placed on cottonseed meal, and both of these had young calves. Of the sixteen animals not eating bone meal eight had to be placed on cottonseed meal.

RESULTS OF THE SECOND YEAR'S OPERATIONS

In the spring of 1925 a large percentage of the cows in pasture No. 2 and pasture No. 4 calved, and this fact must be kept in mind, for it greatly increases the demand for calcium and phosphorus in such animals. Other changes were made on May 2 in so far as some of the animals hitherto used as controls were placed on test to replace the losses and No. 84 and No. 92 previously on test in pasture No. 4 were now placed in the controls because they refused to eat the mixtures.

Thirty new cows were bought from a neighbor, the numbers 111 to 143, inclusive, of which twenty-six were used as new controls. At this time the mineral mixture of pasture No. 2 was changed from a mixture of finely ground rock phosphate, bone meal, and salt in equal parts to a mixture made up of equal parts of bone meal and fine salt. It should be pointed out that cows Nos. 58, 59, 69, and 81, hitherto used as controls, were placed on test because they were known to be bad bone-chewers. Their future behavior in this respect should give us a clue as to the real value of bone meal in breaking this habit.

STATUS OF THE ANIMALS IN THE SPRING OF 1925

Let us first briefly review the condition of the animals at this time, May 1, 1925. This is, of course, the time when new grass is abundant and cattle are expected to mend rapidly. Nevertheless there was a striking difference in favor of the test cows in pastures Nos. 3 and 4. By a peculiar coincidence two cows on test in pasture No. 4, cows Nos. 41 and 48, were, on May 1, 1925, observed to chew bones again for the first time after being broken of the habit. Cow No. 41 has not been observed to chew bones since. Another cow on test in this pasture, cow No. 32, at this time also took to chewing bones again for five weeks. That these three cows should take to chewing bones again may be attributed to the fact that all had young calves, for all had a good record in the consumption of bone meal. A fourth animal, No. 44, later also took to chewing bones again. Of the sixteen control animals in pasture No. 4, ten, or 62 per cent, were still bone-chewers.

Of the cows in pasture No. 3, all of which had been dry since December, 1924, two, cows Nos. 35 and 78, must still be considered as bone-chewers. Cow No. 35 was put on test on November 4, 1924. She had a good record in the consumption of bone meal up to March 5, 1925, when she stopped eating bone meal together with practically all the other cattle and did not start eating it again until July 1, 1925. Cow No. 78 had a rather low and irregular record in the consumption of bone meal, ate no bone meal at all from March 1 to May 1, 1925, and continued very low till August 15, 1925, so that it is not surprising that she should start chewing bones again, the more so since she was a bad bone-chewer from the beginning.

The test cows in pasture No. 2 were on May 2, 1925, changed from a mixture of finely ground rock phosphate, bone meal, and fine salt in equal parts, to a mixture consisting of equal parts of bone meal and fine salt. At this time all cows in pasture No. 2 were in poor condition; in fact, four of the test cows, Nos. 31, 43, 76, and 82, were recorded as creepy at this time, indicating that the mixture they were getting was not effective in preventing this trouble. After these four cows had eaten their new bone meal and salt mixture for ten weeks they had entirely recovered from creeps and did not again get creepy during the following year.

Soon after these cows were placed on their new mixture it became

possible to get a record of their weights at regular intervals. Inasmuch as the weights of the animals could not be obtained before any of them were placed on test, the first weights recorded do not tell the whole story. They do not give a true picture of the real difference between the conditions of the test and control animals, for they tell us nothing of the size of the animals. Even a knowledge of the age of the animals is not enough to supply accurately the needed additional data. It must be kept in mind that we are here dealing with scrub cattle of every description where a pronounced lack of uniformity prevails and where the weight does not indicate the real flesh-carrying capacity of the animal. Measurements of the size of the frame of the animals might help out in interpreting this flesh-carrying capacity, but such measurements are not at hand at this time. The writer may, therefore, be pardoned for burdening the reader with a few remarks on this point. Cow No. 88 has a rather large frame and could carry more flesh and fat than she does, but she is long-legged and naturally does not fatten readily. Cows No. 49 and 79 are of rather small stature, part Jersey, and hence not of a beef type. All the other mature cows are in between these two extremes and their weights probably reflect the maximum results obtainable under the conditions of the experiment. The young, immature cows are naturally not fully developed, light in weight, and represent the normal weight of cows of their age on the present range.

In order that the age of the animal with its influence upon the growth and condition of the same may be brought out more clearly and a better comparison achieved, the following tables are presented in which the age of the animals is used as a basis of division into groups. In reading the tables one must remember that it is palpably unfair to compare the weights of cows nursing calves with dry cows. Since it became necessary to place some of the cows on cottonseed meal to keep from losing them, this fact has been brought out in the tables as clearly as possible.

Table 2. Gain and Loss in Weight of Cows on Bone Meal and Controls 4 Years Old

	Number of Cow	Calf Born	Calf Weaned	Initial Weight on 7–17–25	Highest Weight	Lowest Weight	Pounds Gain at Highest Weight	Per Cent of Initial Weight Gained	Winter Loss in Pounds	Remarks
Cows on bone meal	61	.....	.....	550	630	587	80	14.54	43	On bone meal since 5–2–25
	96	.....	.....	622	717	655	95	15.25	62	On bone meal since 6–25–24
	136	.....	.....	662	800	745	138	20.84	55	On bone meal since 5–2–25
Control cows	77	.....	.....	505	568	*530	63	12.47	38	Advanced pregnancy
	87	2– 5–25	11–30–25	550	646	525	94	17.09	121	
	111	4–29–25	2– 2–26	430	500	450	70	16.27	50	Creepy; fed c. s. m. and b. m.
	113	5–29–25	6–17–25	407	452	412	45	11.05	40	
	116	.....	.....	460	502	*480	42	9.13	22	Advanced pregnancy
	119	.....	.....	465	527	455	62	13.33	72	
	121	.....	.....	422	465	435	43	10.19	30	
	122	.....	.....	462	540	480	78	16.88	60	
	127	5–12–25	2– 2–26	450	525	470	75	16.66	55	Creepy; fed c. s. m. and b. m.
	137	.....	.....	552	630	610	78	14.13	20	
	142	?	2– 1–26	440	530	495	90	20.95	35	Creepy; fed c. s. m. and b. m.
	143	?	.....	415	....	....	....	.....	....	Died with creeps.

*This weight is explained in note under "Remarks" in this table.

Note: c. s. m. and b. m. equals two-thirds pound of cottonseed meal plus four ounces of bone meal per day.

Table 3. Gain and Loss in Weight of Cows on Bone Meal and Controls 5 Years Old.

	Number of Cow	Calf Born	Calf Weaned	Initial Weight on 7–17–25	Highest Weight	Lowest Weight	Pounds Gain at Highest Weight	Per Cent of Initial Weight Gained	Winter Loss in Pounds	Remarks
Cows on bone meal	41	3–19–25	11–30–25	630	730	665	100	15.87	65	
	63	.....	.....	757	940	875	183	24.17	65	Virgin
	79	11– 2–24	6–17–25	630	730	675	100	15.87	55	
	86	6–26–25	7–12–25	627	760	698	103	16.42	62	On bone meal since 5–14–25
	93	6– 6–25	2– 1–26	690	745	620	55	7.94	125	
	95	6–20–25	2– 1–26	570	592	475	22	3.86	117	On bone beal since 5–2–25
Control cows	16	3–17–26	.....	642	747	*615	105	16.19	132	Note calving date
	27	.....	.....	580	660	597	80	13.79	63	Due to calve soon; first calf
	36	2–26–25	6–17–25	490	600	560	110	22.49	40	
	65	.....	.....	600	685	605	85	14.16	80	Virgin
	92	6– 1–25	2– 2–26	532	550	510	18	.....	40	Creepy on 9–25–25 and placed on c. s. m. and b. m.
	94	2–15–25	11–30–25	400	510	475	110	.....	35	Creepy on 7–17–25; placed on c. s. m. and b. m.
	125	?	11–30–25	475	540	500	65	13.70	40	Creepy on 7–17–25 and placed on c. s. m. and b. m.
	132	6– 9–25	3–25–26	595	615	585	20	.....	30	Creepy on 9–11–25 and placed on c. s. m. and b. m.
	133	6– 8–25	2– 2–26	582	582	495	0	0.00	30	Creepy on 8–31–25 and placed on c. s. m. and b. m.
	135	?	2– 2–26	510	510	485	0	0.00	25	Creepy on 8–31–25 and placed on c. s. m. and b. m.

*This weight is explained in note under "Remarks" in this table.

Note: With exceptions noted above cows were place on bone meal on June 25, 1924. c. s. m. and b. m. equals two-thirds pound cottonseed meal plus four ounces of bone meal per day. Last weights considered were taken on April 29, 1926.

Table 4. Gain and Loss in Weight of Cows on Bone Meal and Controls 6 and 7 Years Old

	Number of Cow	Calf Born	Calf Weaned	Initial Weight on 7–17–25	Highest Weight	Lowest Weight	Pounds Gain at Heighest Weight	Per Cent of Initial Weight Gained	Winter Loss in Pounds	Remarks
Cows on bone meal	1	3– 3–26	.....	822	995	*790	173	21.04	205	Note calving date
	11	6–16–25	2– 2–26	687	797	570	0	0.00	117	On bone meal since 5–2–25
	14	.....	.....	657	797	710	140	21.31	87	
	31	3–15–25	11–25–25	710	710	610	0	0.00	100	On bone meal since 5–2–25
	32	2– 8–25	6–17–25	692	822	772	130	18.78	50	
	43	2–13–25	11–25–25	527	590	540	63	11.95	50	On bone meal since 5–2–25
	59	4–19–25	11–30–25	662	662	540	0	0.00	120	On bone meal since 5–2–25
	67	12–27–24	10–20–25	717	805	717	88	12.26	88	
	71	2–14–25	aborted	687	790	707	103	15.00	83	On bone meal since 5–2–25
	78	.....	.....	722	850	795	128	17.72	55	
	81	11–25–24	6–17–25	702	865	785	163	23.36	80	On bone meal since 5–2–25
Control cows	9	12–13–25	.....	747	827	610	80	10.71	217	Note calving date
	18	.....	.....	630	690	640	60	9.52	50	
	24	2–13–25	10–31–25	520	618	*595	98	18.84	23	Creepy; fed c. s. m. and b. m.
	38	.....	.....	630	715	610	85	13.49	105	
	45	2–12–25	10–31–25	517	595	535	78	15.08	60	Creepy; fed c. s. m. and b. m.
	62	.....	.....	652	715	600	63	9.66	115	
	74	3–15–25	10–31–25	445	608	580	163	36.63	28	Creepy; fed c. s. m. and b. m.
	97	12–13–25	.....	750	878	*765	128	17.06	113	Note calving date
	138	5–19–25	aborted	650	755	665	105	16.15	90	

*This weight is explained in note under "Remarks" in this table.

Note: Unless otherwise indicated cows on bone meal since June 25, 1924. Last weights considered were taken on April 29, 1926. c. s. m. and b. m. equals two-thirds pound cottonseed meal plus four ounces of bone meal.

Table 5. Gain and Loss in Weight of Cows on Bone Meal and Controls 8 Years Old or Over.

	Number of Cow	Calf Born	Calf Weaned	Initial Weight on 7-17-25	Highest Weight	Lowest Weight	Pounds Gain at Heighest Weight	Per Cent of Initial Weight Gained	Winter Loss in Pounds	Remarks
Cows on bone meal	8	3-19-25	6-17-25	725	865	780	140	19.31	85	
	15	9- 9-24	11-22-25	820	892	770	72	8.78	122	On bone meal since 5-2-25
	19	2-27-26	.....	712	850	*645	138	19.38	205	Note calving date
	21	3- 5-26	aborted	707	845	750	138	19.52	95	Note calving date
	29	7-20-25	2- 1-26	875	875	*680	0	0.00	195	Note calving date
	34	4- 5-26	.....	722	855	760	133	18.42	95	Note calving date
	35	.....	.....	775	950	860	175	22.58	90	
	49	2-21-25	6-17-25	647	647	595	0	0.00	52	
	55	3-31-25	11-30-25	777	860	750	83	10.68	110	
	58	3- 3-25	11-30-25	682	825	750	143	20.98	75	On bone meal since 5-2-25
	68	8- 9-24	9-15-25	647	707	590	60	9.27	117	
	69	2-15-25	6-17-25	677	850	780	173	25.55	70	On bone meal since 5-2-25
	76	3-12-25	11-25-25	725	735	680	10	1.36	56	Creepy on 5-2-25; on bone meal since 5-2-25
	82	3-11-25	11-25-25	635	650	560	15	2.36	90	Creepy on 5-2-25; on bone meal since 5-2-25
	83	3-17-26	.....	857	1022	*825	165	19.28	197	Note calving date
	88	4- 4-25	6-17-25	810	955	805	145	17.90	150	
	117	?	6-17-25	722	895	802	173	24.01	93	On bone meal since 5-2-25
	131	3-22-26	.....	790	895	*740	105	13.28	155	Note calving date
Control cows	4	3- 3-26	.....	705	795	*620	90	12.76	175	Note calving date
	6	.....	.....	725	817	692	92	12.69	115	
	39	2-22-25	11-30-25	522	570	520	48	9.19	50	
	57	.....	.....	792	852	805	60	7.56	47	
	89	3-22-25	2- 2-26	610	680	655	70	11.49	25	Creepy; fed c. s. m. and b. m.
	124	.....	.....	642	745	617	130	16.04	128	
	126	.....	.....	560	670	630	110	19.64	40	
	129	2-25-26	3- 5-26	775	825	*627	50	6.45	128	Note calving date
	134	8-16-25	2- 1-26	*802	802	597	0	0.00	205	Note calving date
	139	?	11-30-25	802	802	655	0	0.00	247	
	141	.....	.....	712	775	700	63	8.84	75	

*This weight is explained in note under "Remarks" in this table.
Note: Last weights considered were taken on April 29, 1926. Unless otherwise indicated cows were placed on bone meal on June 25, 1924.

The foregoing tables would give a uniform basis of comparison if all test cows had been on the same bone meal mixture and for the same length of time. In view of the fact that this has not been the case, the following tables, in which the period of lactation, the initial weight of the animal on July 17, 1925, the highest weight, the loss in weight during the following winter, the time the animals were on their respective bone meal and salt mixtures (the age of the animals can be obtained from Tables 2, 3, 4, and 5) and the condition of the animals are recorded. Considering all these circumstances, this probably gives us the fairest basis of comparison.

Table 6. Gain and Loss in Weight of Cows in Pasture No. 2

	Number of Cow	Calf Born	Calf Weaned	Initial Weight on 7–17–25	Highest Weight	Lowest Weight	Pounds Gain at Highest Weight	Per Cent of Initial Weight Gained	Winter Loss in Pounds	Remarks
Cows on bone meal	11	6–16–25	2– 2–26	687	797	570	0	0.00	117	
	15	9– 9–24	11–22–24	820	892	770	72	8.78	122	
	31	3–15–25	11–25–25	710	710	610	0	0.00	100	Creepy on 5–8–25
	43	2–13–25	11–25–25	527	590	540	63	11.95	50	Creepy on 5–8–25
	61	.....	.....	550	630	587	80	14.54	43	Virgin
	68	8– 9–24	9–15–25	647	707	590	60	9.27	117	
	71	2–14–25	aborted	687	790	707	103	15.00	83	
	76	3–12–25	11–25–25	725	735	680	10	1.36	55	Creepy on 5–8–25
	82	3–11–25	11–25–25	635	650	560	15	2.36	90	Creepy on 5–8–25
	86	6–26–25	7–12–25	627	760	698	103	16.42	62	
	95	6–20–25	2– 1–25	570	592	475	22	3.86	117	
Control cows	17	11– 2–24	10–20–25	700	700	690	0	0.00	10	
	18	.....	.....	630	690	640	60	9.52	50	
	24	2–13–25	10–31–25	520	618	595	98	18.84	23	Creepy; fed c. s. m. and b. m.
	45	2–12–25	10–31–25	517	595	535	78	15.08	60	Creepy; fed c. s. m. and b. m.
	57	.....	.....	792	852	805	60	7.56	47	
	74	3–15–25	10–31–25	445	608	580	163	36.63	28	Creepy; fed c. s. m. and b. m.
	77	.....	.....	505	568	*530	63	12.47	38	Heavy with calf
	113	5–29–25	6–17–25	407	452	412	45	11.05	40	
	116	.....	.....	460	502	*480	42	9.13	22	Due to calve shortly
	119	.....	.....	465	527	455	62	13.33	72	
	129	2–25–26	3– 5–26	775	825	*627	50	6.45	198	Note calving date

*This weight is explained in note under "Remarks" in this table.

Note: Cows on bone meal since May 2, 1925. c. s. m. and b. m. equals two-thirds pound cottonseed meal plus four ounces of bone meal per day. Last weights considered were taken on April 29, 1926.

Table 7. Gain and Loss in Weight of Cows in Pasture No. 3.

	Number of Cow	Calf Born	Calf Weaned	Initial Weight on 7-17-25	Highest Weight	Lowest Weight	Pounds Gain at Highest Weight	Per Cent of Initial Weight Gained	Winter Loss in Pounds	Remarks
Cows on bone meal	1	3- 3-26	.....	822	995	*790	173	21.04	205	Note calving date
	14	.....	.....	657	797	710	140	21.31	87	
	19	2-27-26	.....	712	850	*645	138	19.38	205	Note calving date
	21	3- 5-26	aborted	707	845	*750	138	19.52	95	Note calving date
	34	.....	.....	722	855	*760	133	18.42	95	Due to calve shortly
	35	.....	.....	775	950	860	175	22.58	90	
	78	.....	.....	722	850	795	128	17.72	55	
	83	3-17-26	.....	857	1022	*825	165	19.28	197	Note calving date
	117	?	6-17-25	722	895	802	173	24.01	93	On bone meal since 5-2-25
	131	3-22-26	.....	790	895	*740	105	13.28	155	Note calving date; on bone meal since 5-2-25
Control cows	4	3- 3-26	.....	705	795	*620	90	12.76	175	Note calving date
	6	.....	.....	725	817	692	92	12.69	115	
	9	.....	.....	747	827	*610	80	10.71	217	Note calving date
	38	.....	.....	630	715	610	85	13.49	105	
	62	.....	.....	652	715	600	63	9.66	115	
	97	12-13-25	.....	750	878	765	128	17.06	113	
	111	4-29-25	2- 2-26	430	500	450	70	16.27	50	Creepy; fed c. s. m. and b. m.
	122	.....	.....	462	540	480	78	16.88	60	
	132	6- 9-25	3-25-26	595	615	585	20	.....	30	Creepy; fed c. s. m. and b. m.
	135	6- 8-25	2- 2-26	510	510	450	0	0.00	60	Creepy; fed c. s. m. and b. m.
	138	5-19-25	aborted	650	755	655	105	16.15	90	
	141	.....	.....	712	775	700	63	8.84	75	
	142	?	2- 1-26	440	530	495	90	20.45	35	Creepy; fed c. s. m. and b. m.

*This weight is explained in note under "Remarks" in this table.

Note: c. s. m. and b. m. equals two-thirds pound cottonseed meal plus four ounces of bone meal per day. Last weights considered were taken on April 29, 1926.

Table 8. Gain and Loss in Weight of Cows in Pasture No. 4.

	Number of Cow	Calf Born	Calf Weaned	Initial Weight on 7-17-25	Highest Weight	Lowest Weight	Pounds Gain at Highest Weight	Per Cent of Initial Weight Gained	Winter Loss in Pounds	Remarks
Cows on bone meal	8	3-19-25	6-17-25	725	865	780	140	19.31	85	
	29	7-20-25	2- 1-26	*875	875	680	0	0.00	195	Note calving date
	32	2- 8-25	6-17-25	692	822	772	130	18.78	50	
	41	3-19-25	11-30-25	630	730	665	100	15.87	65	
	49	2-21-25	6-17-25	647	647	595	0	0.00	52	
	55	3-31-25	11-30-25	777	860	750	83	10.68	110	
	58	3- 3-25	11-30-25	682	825	750	143	20.98	75	On bone meal since 5-2-25
	59	4-19-25	11-30-25	662	662	540	0	0.00	120	On bone meal since 5-2-25
	63	.....	.....	757	940	875	183	24.17	65	Virgin
	67	12-27-24	10-20-25	717	805	717	88	12.26	88	
	69	2-15-25	6-17-25	677	850	780	173	25.55	70	On bone meal since 5-2-25
	79	11- 2-24	6-17-25	630	730	675	100	15.87	55	
	81	11-15-24	6-17-25	702	865	785	163	23.36	80	On bone meal since 5-2-25
	88	4- 4-25	6-17-25	810	955	805	145	17.90	150	
	93	6- 6-25	2- 1-26	690	745	620	55	7.94	125	
	96	.....	.....	622	717	655	95	12.25	62	Virgin
	136	.....	.....	662	800	745	138	20.84	55	Virgin; on bone meal since 5-2-25
Control cows	16	3-17-26	.....	642	747	*615	105	16.19	132	Note calving date
	27	.....	.....	580	660	597	80	13.79	63	Due to calve shortly
	36	2-26-25	6-17-25	490	600	560	110	22.49	40	
	39	2-22-25	11-30-25	522	570	520	48	9.19	50	
	65	.....	.....	600	685	605	85	14.16	80	Virgin
	87	2- 5-25	11-30-25	550	646	525	94	17.09	121	
	89	3-22-25	2- 2-26	610	680	655	70	11.49	25	Creepy; fed c. s. m. and b. m.
	92	6- 1-25	2- 2-26	532	550	510	18	.....	40	Creepy; fed c. s. m. and b. m.
	94	2-15-25	11-30-25	400	510	475	110	.....	35	Creepy; fed c. s. m. and b. m.
	114	?	.....	530	....	....	....	.....	....	Died with creeps
	121	.....	.....	422	465	435	43	10.19	30	
	123	5-12-25	.....	627	....	....	....	.....	....	Died with creeps
	124	.....	.....	642	745	617	130	16.04	128	
	125	?	11-30-25	475	540	500	65	13.70	40	Creepy; fed c. s. m. and b. m.
	127	5-12-25	2- 2-26	450	525	470	75	16.66	55	Creepy; fed c. s. m. and b. m.
	133	6- 8-25	2- 2-26	582	582	490	0	0.00	30	Creepy; fed c. s. m. and b. m.
	134	8-16-25	2- 2-26	*802	802	597	0	0.00	205	Note calving date
	137	.....	.....	552	630	610	78	14.13	20	
	143	?	.....	415	....	....	....	.....	....	Died with creeps

*This weight is explained in note under "Remarks" in this table.

Note: Unless otherwise indicated cows on bone meal since June 25, 1924. c. s. m. and b. m. equals two-thirds pound cottonseed meal plus four ounces of bone meal per day. Last weights considered were taken on April 29, 1926.

As will be seen from Tables 6, 7, and 8 some of the control cows developed creeps during the rather dry summer. Such cases of creeps became apparent especially during the latter half of July, and on August 1 such cows were placed on a mixture of two parts of bone meal and one part of fine salt in order to observe the effects of this mixture upon the course of the trouble. Since these cows were not accustomed to this mixture the consumption at the outset was not satisfactory enough to meet the emergency, and since it was very necessary to get such cows on a concentrated ration as quickly as possible, the bone meal and salt mixture for the creepy cows was changed, on August 18, to a mixture of two-thirds pounds cottonseed meal plus four ounces of bone meal per day and per head. This mixture was

readily consumed and the cows improved satisfactorily but still remained thin. As soon as improvement permitted the cows were taken off this mixture and allowed grazing only, although some of the cows did not continue to improve after being taken off and had to be placed back on again. As winter was approaching and as a supply of cottonseed cake had been purchased for the winter, the above ration was changed to cottonseed cake only on December 28, 1925, and of this two pounds per head per day was fed thereafter until the last could be removed from feed on January 28, 1926. Table 9 shows the cows which became creepy and were fed as outlined above.

Table 9. Creepy Cows Among the Controls Placed on Two-thirds Pound Cottonseed Meal Plus Four Ounces of Bone Meal Per Day.

Number of Animal	Placed on Mixture	Recorded as Recovered from Creeps On	Number of Days on Mixture
45	Aug. 1, 1925	Oct. 1, 1925	150
74	Aug. 1, 1925	Oct. 1, 1925	150
94	Aug. 1, 1925	Oct. 1, 1925	42
111	Aug. 1, 1925	Oct. 1, 1925	110
143	Aug. 1, 1925	.....	Will not eat; died
142	Aug. 1, 1925	Oct. 1, 1925	110
24	Aug. 12, 1925	Oct. 1, 1925	56
89	Aug. 12, 1925	Oct. 1, 1925	44
114	Aug. 12, 1925	.....	Will not eat; died
123	Aug. 12, 1925	.....	Will not eat; died
92	Aug. 31, 1925	Oct. 1, 1925	18
127	Aug. 31. 1925	Oct. 1, 1925	48
132	Aug. 31. 1925	Oct. 1, 1925	42
133	Aug. 31. 1925	Oct. 1, 1925	36
135	Aug. 31. 1925	Oct. 1, 1925	103

Note: In addition to the number of days on cottonseed meal plus bone meal as recorded above, all cows, except the three that died, had to be placed on cottonseed cake during January, 1926.

The creepy cows on cottonseed meal and bone meal were kept in their respective pastures while on this mixture so that they might continue to serve as controls. Although these cows received more bone meal per day than any of the test cows and two-thirds pounds of cottonseed meal in addition, still their gain in weight did not equal that of the test cows in pastures Nos. 3 and 4, but equalled that of the test cows in pasture No. 2. There are probably several reasons for this. In the first place, the creepy cows were not placed on this mixture till August 18, 1925, and hence not enough time had elapsed before winter came on for the mixture to show its greatest efficiency. In the second place, the cows in pasture No. 2 had been on the rock phosphate mixture during the previous year, which mixture proved a failure to the extent that four of the twelve cows on test with this mixture developed creeps in May, 1925, thus virtually placing these four animals on a par with the control animals that became creepy during 1925 and that were placed on cottonseed meal and bone meal and are under consideration here. It is significant that the four test cows in pasture No. 2 which were reported creepy on May 8, 1925, had recovered from this affliction

by July 17, 1925, without having received any concentrate in addition to the three ounces of bone meal allowed per head and per day. In the third place, the individuality of the cow which enables it to withstand adverse conditions plays an incalculable rôle. That such a factor plays an important part is indicated by the fact that the cows Nos. 29, 49, and 59 on test in pasture No. 4 and cow No. 31 on test in pasture No. 2 should not make any gains after July 17, 1925, and by the fact that certain cows show a tendency to become creepy year after year. It is possible that the four cows mentioned above would have developed creeps had they not been fed bone meal. In this connection it is interesting to compare the monthly record in the consumption of bone meal shown in Table 1. But the very fact that such a large number of control cows from the other two pastures developed creeps and very likely would not have survived but for the additional feed allowed, in which case the gain would have been naught, is strong evidence that bone meal fed at the rate of three ounces per head and per day is very effective in preventing creeps.

Upon reading the notes in the column headed "Remarks" in Tables 6, 7, and 8, one will see that during July, August, and September fifteen of the forty-five control cows contracted creeps and had to be placed on cottonseed meal and bone meal in order to relieve the condition, although three of these animals refused to eat this mixture or even pure cottonseed meal, and died with creeps before winter was at hand. Of the twelve remaining creepy cows placed on cottonseed meal and bone meal, two were placed on test in pasture No. 4 (cows No. 89 and 94) on September 14, six were taken off the mixture on October 7 and one on October 24. Two of the cows taken off the mixture on October 7 and the cow taken off on October 24 did not improve satisfactorily thereafter and hence were put back on the same mixture on November 16. The two remaining cows of the creepy lot, cows Nos. 45 and 74, did not improve enough so that they could be taken off and hence were kept on the mixture till December 28, 1925, and were then placed on cottonseed cake alone till January 28, 1926. The three cows, Nos. 111, 135, and 142, placed back on the cottonseed-meal and bone-meal mixture on November 16, 1925, were handled exactly like cows Nos. 45 and 74. It should be noted, however, that these five cows no longer showed symptoms of creeps on October 17, but were kept on because they were so thin. It is of interest to note their weight record.

As winter approached it is but natural to expect some animals to lose in flesh, and hence it is not surprising that in December cows were getting so poor that it was deemed advisable to place them on some concentrated feed. Thus, on December 17, the formerly creepy cows Nos. 127 and 133 and the control cow No. 139, and on December 20 and 24, respectively, the control cow No. 92 and the test cow No. 11 were placed on cottonseed cake. To these cows were added on December 28 the following: Test cows Nos. 29, 31, 43, 76, 89, 94, and 95 and control cows Nos. 17, 132, and 134. Regarding the test cows added on the above date it should be recalled that Nos. 89 and 94 were not placed

on test till the middle of September, 1925, at which time they had already developed creeps. With the exception of test cow No. 29, which was grazing in pasture No. 4, all the test cows placed on cottonseed cake had been assigned to posture No. 2. To further clarify the situation it may be stated that the test cows Nos. 31, 43, and 76 were creepy in *May, 1925, at the time they were placed on test on the bone-meal and* salt mixture and No. 95 was a young cow with her first calf. All these cows were kept on a daily ration of two pounds of cottonseed cake from December 28, 1925, to January 28, 1926.

What, now, is the final result in terms of gain in weight of the test cows as compared with the control cows? By adding the total gain made after July 17, 1925, by the thirty-eight animals on bone meal and salt mixture and subtracting from it the total gain made by the forty-five control cows, one will find a difference of seven hundred and *five pounds' gain in favor of the thirty-eight cows fed bone meal and* salt. This is indeed a creditable showing. In analyzing the result, however, one must consider that the greatest gain had not been attained till October and November, a time at which eleven of the forty-five control animals had already been on special feed for a considerable length of time.

ANIMALS LOST

Anyone engaged in the production of live stock is not only interested therein from the standpoint of gain in weight of the individual animal, but he is also vitally interested in the loss of animals by death, for the loss may indeed outweigh all the gains of the surviving animals. Particularly important in the particular region where the work reported here is being carried on are those diseases which we have not let learned to control or where the death is due to causes not yet thoroughly established. In tabulating the losses at our Loin Disease Field Laboratory that would come under these two categories, we find that nine animals died of unknown causes; that is, loin disease could certainly be excluded, but no opportunity was had to make a post-mortem examination. Since all animals had been vaccinated for anthrax, the author feels safe in excluding that disease, especially since the circumstances attending the death of these animals would not speak for anthrax. It appears, therefore, that some other cause or causes are at work which may or may not be the result of a mineral deficiency. It is at least significant that in nine out of forty animals lost at the laboratory during the two years it has been in operation no definite cause could be assigned. Of the remaining thirty-one animals lost eight perished during the severe freeze in December, 1924, fourteen died with loin disease, two with anthrax, three with creeps, and the remainder with other known causes. When we exclude the eight animals which perished during the freeze we find that all but five of the animals lost were control animals. Of the five animals on test, one developed numerous tumors throughout the body and died as the result of these; two died from loin disease after they took to chewing bones again in the summer of 1925, and two died from

loin disease before the bone-chewing habit had been broken. Table 10 shows the distribution of the control animals lost exclusive of those that perished during the freeze and those that died of anthrax.

Table 10.

Died of Loin Disease	Creeps	Unknown	Other Causes
11	3	9	3

It should be kept in mind that, exclusive of calves, eighty-eight animals were placed on the grounds of the laboratory in June, 1924, and to these, thirty animals were added on May 1, 1925, making a total of one hundred and eighteen animals concerned. Only one-half of these, or fifty-nine animals, were used as controls; that is, they were kept in the same pasture as the test animals under ordinary grazing conditions as practiced in the region concerned. Using the figures given in Table 10 one finds that 44 per cent of the control animals died within two years from causes we must seek to control.

INFLUENCE OF FEEDING BONE MEAL TO THE COWS UPON THE DEVELOPMENT OF THE CALVES

It is of interest to note the effect of feeding bone meal to the mother animal upon the weight and development of the calves of such animals as compared with the calves of the control animals. Unfortunately the number of calves available for such a comparison is rather small, as some of the calves had been sold to a butcher before scales were at hand. Inasmuch as the calves were not all born on the same day, and inasmuch as the weights were taken at regular intervals, the weights given in Figure 5 are computed at two hundred days old.

Figure 5 represents the weights graphically. In reading and interpreting the chart one must bear in mind that test cows Nos. 43, 76, and 82 were reported creepy on May 8, 1925. This date, falling within the two hundred days under consideration, was at a rather critical time in the life of their calves and is reflected in the daily gains of the calves. All three of these cows were grazing in pasture No. 2. No analysis of the chart is necessary; the weights speak for themselves.

RECOMMENDATIONS

The feeding of bone meal is recommended for range cattle on the Coastal Plains of Texas and wherever cattle exhibit symptoms as described herein. For this purpose, mixtures with salt such as two parts of bone meal to one part of salt or three parts of bone meal to two parts of salt are recommended.

SUMMARY AND CONCLUSIONS

In the latter part of June, 1924, twenty dry cows were placed on a mixture of two parts of bone meal and one part of salt in a pasture in Harris County, Texas, and twenty dry cows acted as controls in the same pasture. Two of the cows offered the bone-meal and salt mixture refused to eat it and one of these developed creeps soon after she

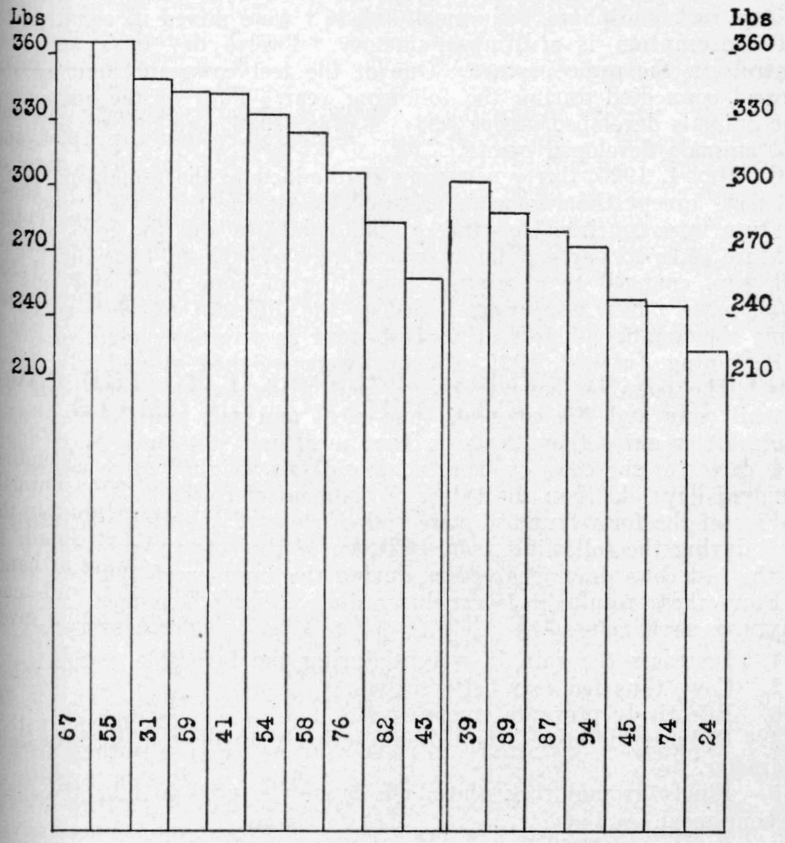

Figure 5. Weights of calves at 200 days of age.
Left: Calves from cows on bone meal.
Right: Calves from control cows.

dropped a calf. Three of the test animals and seven of the control animals died during the following year.

On the same date twelve other cows nursing calves were placed on pure bone meal in an adjoining pasture and eleven cows nursing calves and one dry cow were used as controls. The cows on test refused to eat the pure bone meal, and on August 2, 1924, they were offered in-

stead a mixture consisting of three parts bone meal and two parts salt. This mixture is eaten readily. At the time this change was made two of the test cows were creepy. Of the control cows six cows nursing calves developed creeps during the summer. Four test animals and four control animals died during the following year.

Beginning early in July, 1924, twelve other dry cows were offered different mixtures of finely ground rock phosphate and salt but they refused to eat them. Better consumption was secured when finely ground rock phosphate, bone meal, and salt were mixed in equal parts, but consumption is still unsatisfactory. Twelve dry cows acted as controls in the same pasture. One of the test cows and four of the control cows died during the following year. Four of the remaining test animals developed creeps early in May, 1925, and one of the control animals developed creeps.

On May 1, 1925, thirty new cows were added to the remaining cows. All cows except the two which refused to eat the bone meal and salt mixture were continued on the original mixtures and the cows on the mixture of equal parts of finely ground rock phosphate, bone meal, and salt were changed to a mixture consisting of bone meal and salt in equal parts. New cows were added to the different test lots so as to bring the number on test up to forty-four as originally planned.

Beginning July 17, 1925, all cows were weighed at monthly intervals. The cows on bone meal and salt made better gains than the control cows and the cows on bone meal and salt since June, 1924, made better gains than those on bone meal and salt since May, 1925. The calves of the cows on bone meal and salt weighed more when two hundred days old than the calves of the control cows.

Five of the forty-four test cows and thirteen of the fifty control cows died during the following year. Fifteen of the control cows and none of the test cows developed creeps during the summer of 1925.

From these results it is concluded that feeding bone-meal and salt mixtures as here used

1. Increases the gain in weight during the favorable season.
2. Cows thus fed rear better calves.
3. Effectively prevents creeps.
4. Reduces the losses from diseases other than those of an infectious character.
5. Finely ground rock phosphate cannot be used to take the place of bone meal.

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